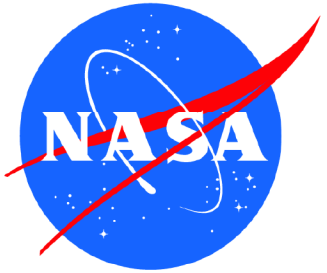
National Aeronautics and Space Administration

# Testing High Precision Space Receivers versus LightSquared Interference




Session B2: Spectrum and Interference Issues

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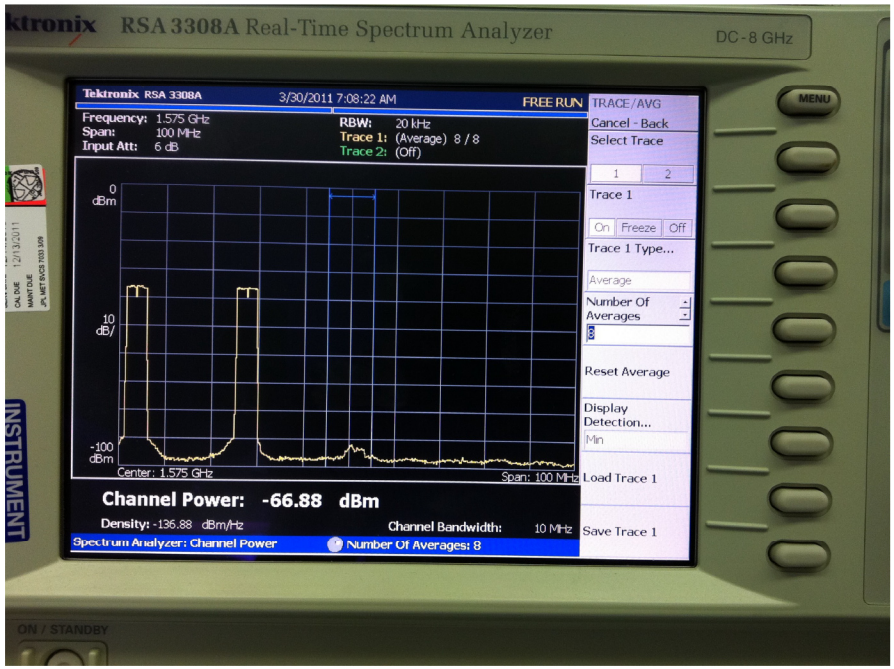
# The Spectrum as seen by a passive GPS antenna

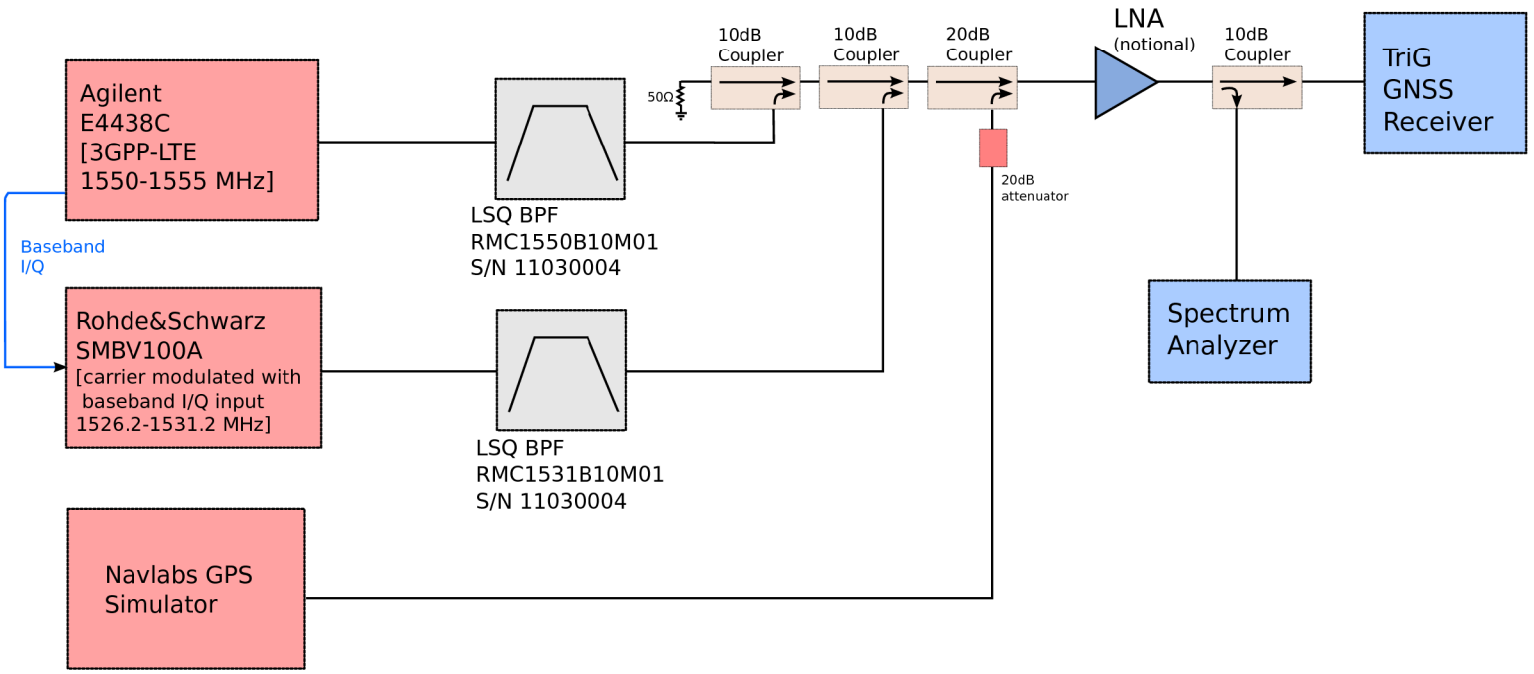
- Expected interference effects
  - Intermodulation
  - Saturation
  - Raising in-band noise floor
- Consequences on GPS tracking performance
  - Decrease in SNR → Increased observables scatter
  - Decreased ability to acquire and track weak signals

[Diagram indicating GPS antenna + frontend, showing signal and noise powers collected. Conducted test needs to recreate the same levels to be realistic]



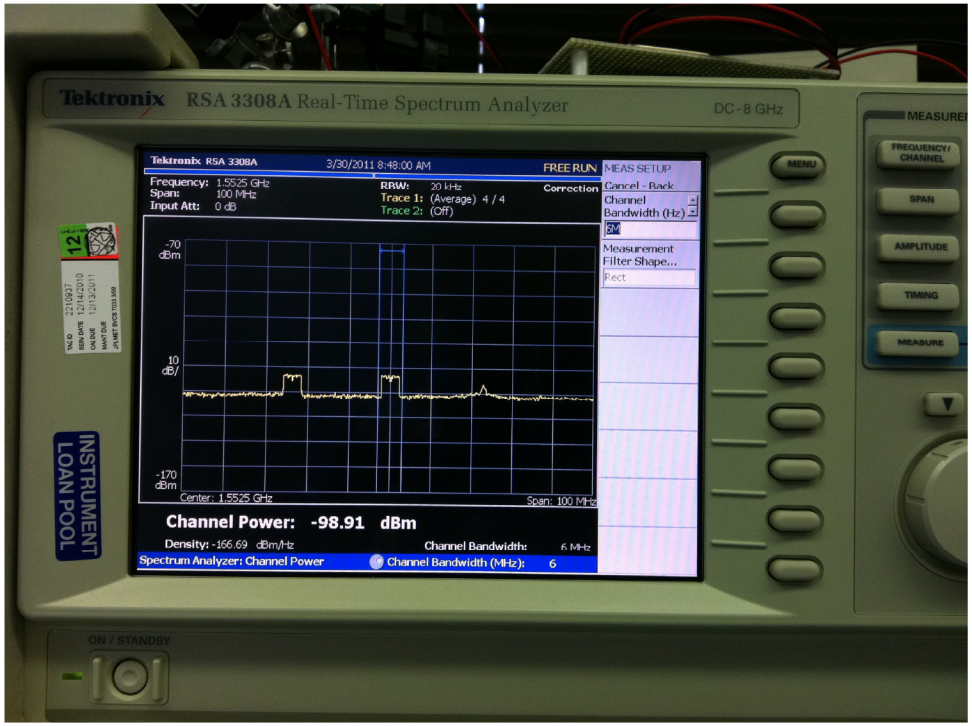
# Conducted test: Let's recreate what the antenna sees

## Overview of conducted test setup

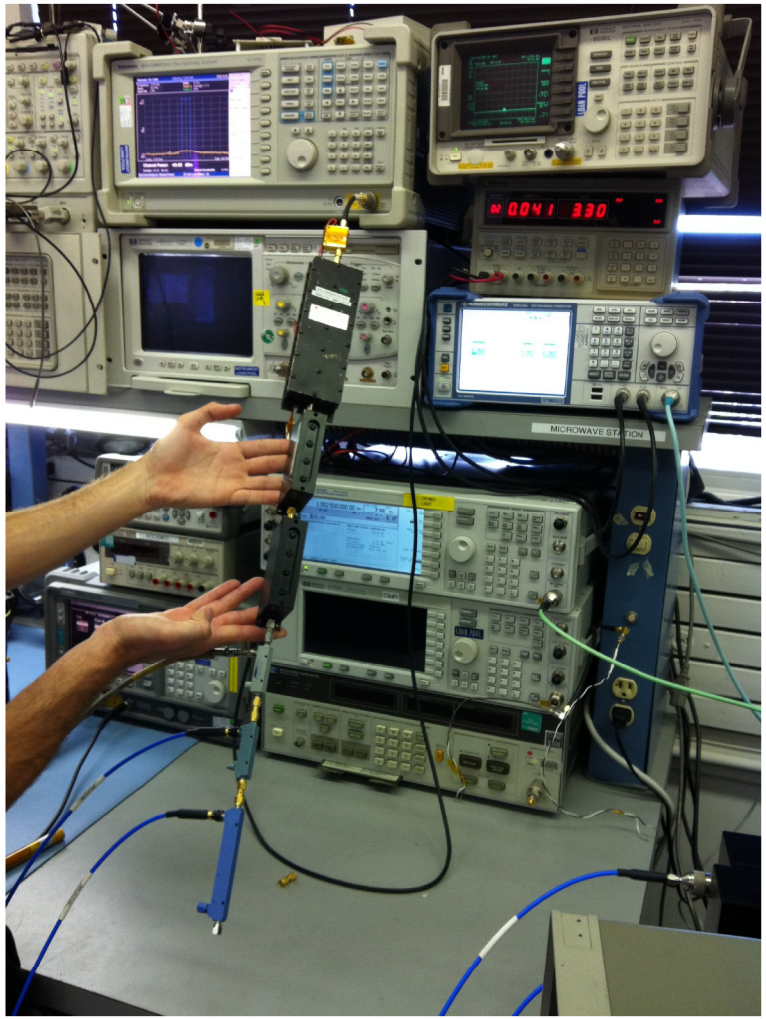


# Signal Generation

- Don't neglect the broadband noise floor of the signal generators → use Lightsquared filters [xxx dBc/Hz]
- Verify modulated LightSquared signal powers on a spectrum analyzer with the ***channel power*** function
- Verify output signal power of GPS simulator



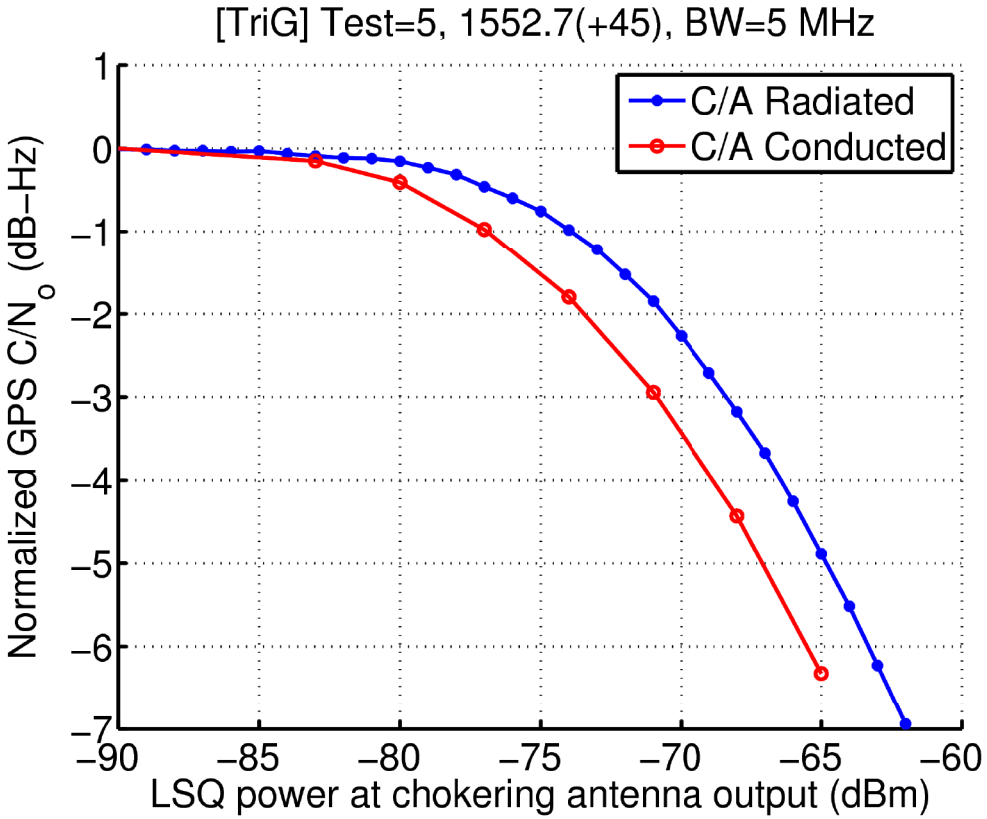
# Importance of controlling the input thermal noise floor

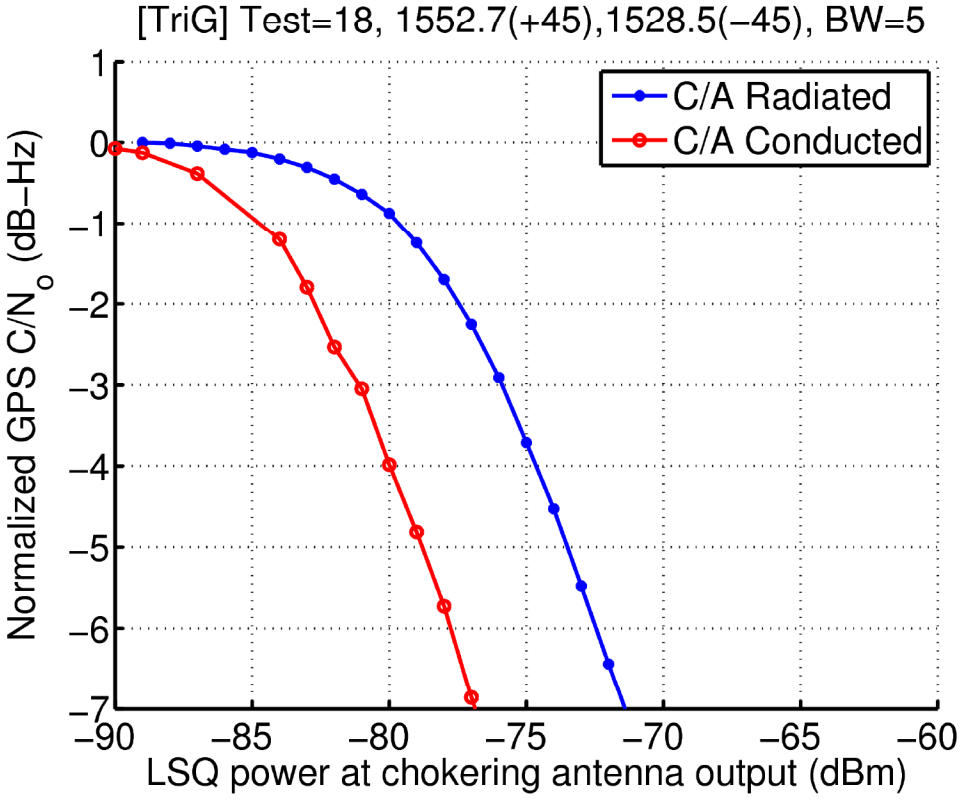


- Should be <300K to be realistic. Why: To report realistic interference susceptibility
- Noise floor: Set by 50 Ohm resistor at ~300K
- Use directional couplers
- Verify the GPS noise floor stays at 300K in the presence of high-powered Lightsquared signals (watch out for inter-mod effects in test equipment!)

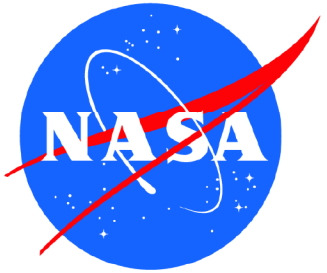
# Results (Conducted and Radiated)

- 1-channel Test (Saturation),
- 2-channel Test (Intermodulation)
- [Table comparing the 3 tests]



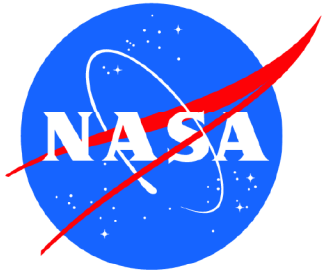



# Conducted test conclusions



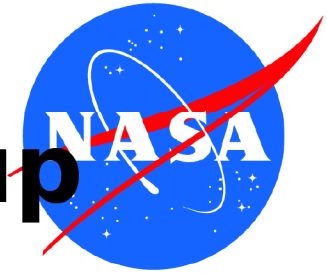

- Intermodulation is real
  - Any mitigation techniques must take it into account
- Must get rid of LightSquared power before the first amplifier.
- For space-borne GPS instruments, we need 40dB of rejection at the LightSquared frequencies BEFORE the first amplifier (LNA).

# Mitigation: pre-LNA Filter



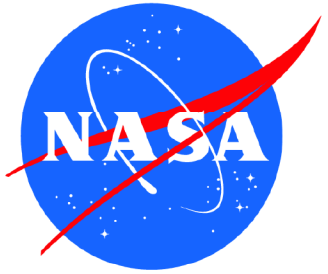

- Requirements
  - Rejection of Lightsquared signals
  - Passband insertion loss
  - Group delay performance (Delay is the main observable of a GPS receiver)
- Implications (table)
  - Many stages: effect on
- Note: Difficult filter to build

# Essential filter property for precision GPS receivers: Group Delay



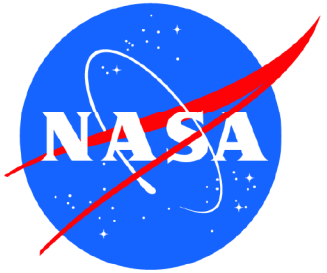

- Why does this matter?
- Group delay stability over environmental changes (temperature)
- Flat over passband
- Stable over temperature
- Flat over expected doppler space [show simulations]
- Stable delay between GPS L1/L2/L5 frequencies (needed for TEC measurement)

# How to meet these group delay requirements




- ***Low group delay: Why?***
  - Temperature effects on filter
- In the past, precision GPS receivers used wideband filters [reference Ed Power's paper, diagrams]
- Adding close in rejection requirements of the LSQ signals ***complicates the filter implementation***
  - High rejection, temperature stability and low insertion loss seem to imply an exotic filter design.

# Conclusion: How to test any mitigation solution




- Measure susceptibility to interfering signals with a conducted test
- Measure new system temperature
- Measure delay performance (over temperature, over doppler, and between GPS L1/L2/L5 frequencies)